

CLAIMS

1. A forging method using a swaging apparatus equipped with a fixing die for fixing a bar-shaped raw material, a guide having an insertion passage for inserting and
5 holding the raw material in a buckling preventing state, and a punch for pressing the raw material inserted in and held by the insertion passage of the guide in an axial direction of the raw material,

wherein a scheduled enlarged diameter portion of the raw material fixed to the fixing die with the scheduled enlarged diameter portion protruded is inserted into the
10 insertion passage of the guide, and

thereafter, while pressing the raw material with the punch by moving the punch, in a state in which a part of a peripheral surface of an exposed portion of the raw material exposed between the guide and the fixing die is restrained or an entire peripheral surface of the exposed portion of the raw material is not restrained, the scheduled enlarged diameter
15 portion of the raw material is subjected to swaging processing by moving the guide in a direction opposite to a moving direction of the punch so that a length of the exposed portion of the raw material becomes a buckling limit length or less at a cross-sectional area of the exposed portion of the raw material.

20 2. The forging method as recited in claim 1, wherein an initial clearance having a distance is provided between the guide and the fixing die prior to an initiation of a movement of the punch, the distance being set to be the buckling limit length or less at a cross-sectional area of the exposed portion of the raw material exposed between the guide and the fixing die.

25 3. The forging method as recited in claim 2, wherein a time lag is provided between the initiation of the movement of the punch and an initiation of a movement of the

guide.

4. The forging method as recited in claim 3, wherein the time lag is set such that a total volume of a volume of the exposed portion of the raw material exposed within a range of the initial clearance at the time prior to the initiation of the movement of the punch and an increased volume of the raw material to be increased during the time lag within the range of the initial clearance does not exceed a volume of the raw material existing within the range of the initial clearance in a scheduled shape of the enlarged diameter portion of the raw material to be formed by the swaging processing.

5. A forging method using a swaging apparatus equipped with a fixing die for fixing a bar-shaped raw material, a guide having an insertion passage for inserting and holding the raw material in a buckling preventing state, and a punch for pressing the raw material inserted in and held by the insertion passage of the guide in an axial direction of the raw material,

wherein a scheduled enlarged diameter portion of the raw material fixed to the fixing die with the scheduled enlarged diameter portion protruded is inserted into the insertion passage of the guide, and

thereafter, while pressing the raw material with the punch by moving the punch, in a state in which a part of a peripheral surface of an exposed portion of the raw material exposed between the guide and the fixing die is restrained or an entire peripheral surface of the exposed portion of the raw material is not restrained, the scheduled enlarged diameter portion of the raw material is subjected to swaging processing by moving the guide in a direction opposite to a moving direction of the punch,

where

"P" is an average moving speed of the punch from an initiation of a movement thereof;

"G" is an average moving speed of the guide from an initiation of the movement thereof;

"X₀" is a buckling limit length at the cross-sectional area of the raw material before the swaging processing;

5 "X₁" is a buckling limit length at the cross-sectional area of the enlarged diameter portion of the raw material after the swaging processing;

"X" is an initial clearance between the guide and the fixing die ($0 \leq X \leq X_0$);

"t₀" is a time lag from the initiation of the movement of the punch to the initiation of the movement of the guide ($0 \leq t_0$);

10 "L" is a length of the enlarged diameter portion of the raw material after the swaging processing;

"l₀" is a length of the raw material in the state prior to the swaging processing required for the enlarged diameter portion; and

15 "T" is a swaging processing time from the initiation of the movement of the punch,
if $t_0 < T$,

"G" satisfies the following relational expression:

$$(L-X)/[(l_0-L)/P-t_0] \leq G \leq P(X_1-X)/(l_0-X_1-Pt_0).$$

20 6. The forging method as recited in claim 5, wherein the scheduled enlarged diameter portion of the raw material is an end portion of the raw material.

7. The forging method as recited in claim 5, wherein the scheduled enlarged diameter portion of the raw material is an axial central portion of the raw material.

15 8. The forging method as recited in claim 5, wherein the scheduled enlarged diameter portion of the raw material is one end portion of the raw material and the other end portion thereof, wherein the one end portion and the other end portion of the raw material

fixed to the fixing die with one end portion and the other end portion protruded are inserted into the insertion passage of the corresponding guide, and wherein the one end portion and the other end portion are simultaneously subjected to swaging processing.

5 9. The forging method as recited in any one of claims 1 to 8, wherein an edge portion of a leading end surface of the guide at a side of the insertion passage and/or an opening edge portion of a raw material fixing and fitting aperture formed in the fixing die are beveled.

10 10. The forging method as recited in any one of claims 1 to 9, wherein the scheduled enlarged diameter portion of the raw material is subjected to swaging processing with a part of a peripheral surface of the raw material restrained by a restraining die portion having a forming dented portion, and thereafter the enlarged diameter portion of the raw material is pressed with a second punch provided at the restraining die portion to thereby fill
15 the forming dented portion with the material of the enlarged diameter portion by plastically deforming the enlarged diameter portion within the forming dented portion of the restraining die portion.

 11. The forging method as recited in claim 10, wherein the fixing die is provided
20 with a flash forming dented portion continuing from the forming dented portion of the restraining die portion, and wherein the material of the enlarged diameter portion is filled into the forming dented portion and the flash forming dented portion by plastically deforming the enlarged diameter portion within the forming dented portion of the restraining die portion.

25 12. The forging method as recited in claim 10, wherein the forming dented portion is a closed dented portion.

13. A forged product obtained by the forging method as recited in any one of claims 1 to 12.

14. A forging apparatus, comprising a swaging apparatus,

wherein the swaging apparatus includes:

a fixing die for fixing a bar-shaped raw material;

a guide having an insertion passage for inserting and holding the raw material in a buckling preventing state;

a punch for pressing the raw material inserted in and held by the insertion passage of the guide in an axial direction of the raw material; and

a guide driving device for moving the guide in a direction opposite to a moving direction of the punch so that a length of the exposed portion of the raw material exposed between the guide and the fixing die becomes a buckling limit length or less at a cross-sectional area of the exposed portion of the raw material.

15. The forging apparatus as recited in claim 14, wherein the swaging apparatus performs swaging processing in a state in which a part of a peripheral surface of the exposed portion of the raw material is restrained or an entire peripheral surface of the exposed portion of the raw material is not restrained.

16. The forging apparatus as recited in claim 14 or 15, wherein the swaging apparatus further includes a restraining die portion for restraining a part of the peripheral surface of the exposed portion of the raw material.

17. The forging apparatus as recited in claim 16, wherein the restraining die portion is provided with a second punch for pressing the enlarged diameter portion of the raw material formed by the swaging apparatus and a forming dented portion into which the

material of the enlarged diameter portion is filled by the pressing of the enlarged diameter portion by the second punch.

18. The forging apparatus as recited in claim 17, wherein the fixing die is provided
5 with a flash forming dented portion continuing from the forming dented portion of the restraining die portion.

19. The forging apparatus as recited in claim 17, wherein the forming dented
portion is a closed dented portion.